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Teaching unit on physical science
Lessons/ learning center/ reviews

States of Matter

Standards:

A substance has characteristic properties, such as density, boiling point, and solubility, all of which are independent of the amount of sample.

Define and give examples of the three states of matter.

Engage:

Present students with the question, "How can you tell which state of matter a compound is occupying?" Have available a variety of solid objects like wood blocks, rocks and marbles of various sizes, a variety of liquids like water, cooking oil, and rubbing alcohol, and a variety of gas filled balloons, helium, air, and oxygen and carbon dioxide if possible.

Explore:

Allow students working in small groups of 2 or 3 to investigate and examine the items provided. Have each group work on one state of matter at a time. Encourage the student's to note similar characteristics among the items. Ask probing questions like, "What makes a gas a gas?"

Explain:

Give the students time to gather their data and develop a concept within their group about the properties of the state of matter they were investigating. Have each group present their results and concept to the rest of the class. Using the information provided by the individual groups, lead a discussion directing the students towards an acceptable definition for each state.

Elaboration:

Using the definitions agreed on by the class, have each group pick a different state of matter to test. Have the groups present their findings and revise definitions as necessary. It would also be beneficial to encourage the students to think about changes in states of matter like boiling and freezing.

Evaluation:

Ask each student in turn to give a definition for the three states of matter and give and example each. Assign grades based on the completeness of the definitions and accuracy of the example.

This activity would correspond to a level 2 inquiry. Beyond the initial question, which is provided, the students are open to determine how they will evaluate each item. The class as a whole is responsible for describing the three states of matter, in practical working definitions.

Density

Standards:

A substance has characteristic properties, such as density, boiling point, and solubility, all of which are independent of the amount of sample.

Determine mass and volume of various objects and calculate their density as mass/volume.

1) Commit to an outcome:

Using a set of density blocks assign groups of students three each. Instruct the students to make predictions as to which blocks will float and which blocks will sink in a beaker of water, and record those predictions in a data table in their science notebooks.

2) Expose beliefs:

Have the students discuss their predictions/ideas within their groups and then with the class as a whole. Encourage students to modify their predictions if necessary based on the input of others.

3) Confront Beliefs:

Have the students test their blocks individually and record which blocks sink and which ones float. Allow the students to present their findings to the class.

4) Accommodate the concept:

Using other materials like rulers, mass balances, scales, and graduated cylinders instruct the students to calculate the densities of each block based on the formula mass/volume.

5) Extend the concept:

Encourage the students to determine if there is a relationship between the blocks that float and those that don't. Ask the students if it would make a difference if other liquids instead of water were used, like cooking oil or rubbing alcohol. Have the students give predictions for their blocks in other liquids and explain their reasons.

This activity starts out as a level two inquiry because the methods are given for everything except how to determine the masses and volumes, but the results are not known ahead of time. It would become a level three activity if the students were allowed to explore the behavior of their blocks in other liquids.

Solubility

Standards:

A substance has characteristic properties, such as density, boiling point, and solubility, all of which are independent of the amount of sample.

Investigate the effects of temperature on the solubility of a substance.

Classify substances based on melting points, boiling points, and solubility data.

Engage:

Present students with the question, " How does temperature affect a substance's ability to dissolve?" Materials to be presented should include plastic cups, sugar cubes, and thermoses of hot, cold, and room temperature water. Stopwatches and thermometers should be available also.

Explore:

Have the student's work in small groups of no more than three to determine exactly what they are going to test and how they will test it. Allow them to perform their tests and collect and record their data in an appropriate data table. Encourage students to discuss their results within their group and make analogies to molecule movement with respect to temperature.

Explain:

Have each group present their procedures and data to the class. The teacher will use the individual explanations to define and clarify key scientific terms like solute and solvent.

Elaborate:

Other solvents like rubbing alcohol, and cooking oil as well as other solutes such as salt and gelatin should be made available to the students. Students will repeat the explore and explain sections using the additional materials and new vocabulary.

Evaluate:

The teacher should use an assessment form throughout the activity to keep track of each student's participation and contribution. The teacher should also ask questions to the class and have them record their answers in their science notebooks.

This lesson corresponds to a level 2 inquiry because only the initial question is provided. The students must develop their own methods and are responsible for the outcomes. After the elaborate stage of the activity it becomes a level three inquiry, as the students must decide which aspect of solubility they want to explore.

Determining acids and bases

Standards:

Substances are placed in categories or groups if they react in similar ways; metals are an example of such a group.

Distinguish between acids and bases using indicators.

Relate the pH scale to the colors of indicators and relative strengths of acids and bases.

Engage:

Discuss with students the concept of acids and bases and the pH scale. Present the students with a liquid indicator of pH (purple cabbage indicator) and four unknown liquids to test. The unknowns should be water, white vinegar, ammonia, and corn syrup. *An acid will turn red, a base will turn green, and a neutral substance will remain purple.

Explore:

Encourage students to investigate other properties of the liquids such as smell, color, and density. Have the students formulate predictions about the identities and possible properties of the unknowns. Allow each group to test the unknowns to determine whether they are acids, bases, or neutral.

- **It is an important safety point to remind the students not to taste any of the unknowns during their investigations.**

Explain:

Have the class report their findings and compile all the results into a data chart. Make sure that the students copy all of the data into their science notebooks. Explain to the students that a solution that turns red indicates an acid, green indicates a base, and purple indicates a neutral substance. Tell the students what the unknowns were.

Elaborate:

Encourage the students to evaluate the results in regards to their predictions. Have them make new predictions about other substances that might be acids or bases giving reasons why they believe so.

Evaluate:

Have each student describe what he or she has learned in class. A complete answer should include that some substances are acids and some are bases, while pure water is neutral. They should also be able to describe which color change indicates which.

This activity is a level 1 inquiry. The question and methods for testing it are provided for the students although they are encouraged to explore other properties of the substances. The only open part of the inquiry is the answer because the students don’t know what the substances are.

The learning center for this unit in the physical sciences will contain three separate activities. The activities relate to the physical properties and changes of matter focusing on chemistry. They are an investigation into density and water displacement, solubility using chromatography, and pH using indicator strips.

Activity 1: Make an object out of a ball of clay that will float.

Standards: Investigate the direct relationship between the amount of water an object displaces and the objects volume.
Relate the properties of sinking and floating to different densities of substances.

Object: The goal of this activity is to transform the ball of clay (which will not float) into some other form that will be able to float and even hold additional weight.
Try to make the clay support as much weight as possible without sinking.
Record the amount of weight added in pennies next to your name on the data sheet provided.
The winner will win some prize at the end of the month.

Materials: A few balls of clay of equal size will be provided for the students to work with.
A dish of pennies to be used as weight will also be available for use.
An aquarium or other large container half full of water is needed for the students to float their objects in.

Activity 2: Determine the pigments in different markers using chromatography.

Standards: Investigate and describe how solubility differences can be used to identify components of a mixture (e.g.chromatography).

Object: The goal of this activity is to use the materials provided to determine if and what different pigments are used in a variety of water soluble markers.

Instructions: 1) Take one strip of the filter paper and make a spot on it with one of the markers about ¼ inch from the bottom.
2) Attach the filter paper to the paper clip attached to the lid of the jar.
3) Place the lid of the jar back on to the jar and allow the solvent (water) to carry the pigments (solute) up the filter paper.
4) Observe as the pigments separate as they travel up the filter paper.

5) try it with several different colors and note any differences that you see.

Set-up: This activity requires several different colored pens to be used. The filter paper should be cut into strips just long enough so the tip touches the water when the lid is in place. There should only be a small amount of water in the bottom of the jar.

Activity 3: Determining the pH of different substances.

Standards: Distinguish between acids and bases using indicators.

Object: The object of this activity is to determine the pH of a wide variety of different substances.

Instructions: The students should be encouraged to bring in different things from around the house that they would like to test such as lemon juice, cleaning products, tomato juice, alka seltzer, etc.
2) After testing the substance the pH and name of the substance should be recorded on the data sheet provided.

Materials: All that is required for this activity is to provide litmus paper strips for testing and an appropriate data sheet for recording the results.

Goodwin, A. (2002). Is salt melting when it dissolves in water? Journal of Chemical Education, 79(3), 393-396.

The concept discussed in this article relates to a scientific concept that can result in misconceptions for the student as well as the teacher. The difference between melting and dissolving seems so obvious that many teachers are concerned when children interchange them, according to Alan Goodwin of the Institute of Education at Manchester Metropolitan University. However, the distinction becomes less clear when checking a dictionary and finding the word dissolve in the definition of melting. The subtleties in the technical differences between melting and dissolving are discussed at length but are well beyond the scope of elementary education and are best left to high school and college level chemistry courses. The important distinction to be made at the elementary level that

melting most appropriately refers to the case of a single substance being turned from the solid to the liquid state by increasing temperature.

The article shows how rigid thought and simple definitions at the elementary level can lead to difficulties in understanding more intricate and technical definitions later on. Although the working definition for melting provided above allows the student to distinguish it from the concept of dissolving it is important not to overemphasize this difference. It is also important for the elementary school teacher to realize that the technical difference between melting and dissolving is actually quite obscure and should not be too rigid in applying definitions.

The information provided in the article is unlikely to change the information taught at the elementary level. It does, however provide the elementary educator with a better understanding of an apparently obvious concept. By better understanding the subtle differences between melting and dissolving at a deeper level it seems more appropriate to de-emphasize the rigid distinction at the elementary level. Goodwin states that it is important to find an appropriate balance with sufficient certainty to render a classification or definition meaningful or useful and sufficient flexibility to facilitate further learning and re-examination of the ideas in the future. Instead of addressing the issue as a student's misconception of melting versus dissolving it is more accurately viewed as a misconception of a misconception. In order to prevent the development of a misconception it is important to stress to the students that many scientific concepts are much more complicated than they appear on the surface.

Stavy, R. (1991). Children's Ideas about Matter. School Science and Mathematics, 91(6), 240-244.

The article discusses misconceptions and difficulties with the concept of matter. A study was conducted using 80 students ranging from first to seventh grades. The students were first asked to verbally explain what matter is. Then the students were asked to classify a series of items as matter or not. The material items were solids, powders, liquids, biological materials, and air. The non-material items consisted of phenomena directly associated with matter like fire, electricity, wind, and smell, as well as items like light, heat, and shadow.

Explanations of matter fit into four major categories: by example, by function, by structure, and by properties. Children in the lower grades typically tend to explain matter by giving examples or describing function and not by defining features. This indicates that younger children associate matter with moldable or useful solids. It is not until the 7th grade, and then only a small percentage, that students will relate the properties of weight and volume to matter.

Although children have no problems identifying solids as matter and light, heat, and shadow as non-matter, a large number of students had trouble with placing gas as matter and phenomena associated with matter as non-matter. This difficulty is attributed to the child's lack of a formal definition for matter and their reliance on practical working definitions. This seems consistent with most misconceptions where common usage and definitions affect a child's ability to grasp scientific concepts. It is important, therefore, to begin in the early grades with the concept of defining matter by its properties, especially mass and volume.

It is probably important to begin with items that students are easily able to classify as matter, by identifying common features and properties. The author then suggests moving gradually to more difficult items like liquids and gasses to see if they posses the identified properties. By allowing the students to investigate the association of material items with measurable properties through inquiry methods they are likely to gain a better understanding of why certain phenomena are not matter and gasses and liquids are.